2019

Visualization and Scientometric Mapping of Global Agriculture Big Data Research

Guptnath Trivedi
gupt.bhu@gmail.com

Visualization and Scientometric Mapping of Global Agriculture Big Data Research

Guptnath Trivedi
Assistant Librarian
Dr. Rajendra Prasad Central Agriculture University, Pusa, Samastipur, Bihar-848125
email: gupt.bhu@gmail.com

Abstract:
The present paper is a scientometric and visualization study of global Agriculture Big Data (ABD) research. however as per the quantification is concern, very little research have performed in the area of Agriculture Big Data. The study aims to traverse the present status of Agriculture Big Data research through network analysis and visualizations study of the ABD publications. A total of 379 publication data were downloaded from Clarivate Analytics Web of Science database within the time span of "all years". VOSviewer, MS-Excel and R statistical softwares are used for data analysis. Various results are drawn based on annual scientific production, most cited papers, most cited authors, most cited affiliations, most prolific nations, author's h-index, co-authorship analysis of countries and organizations, co-citation analysis of sources, the keyword co-occurrence analysis and density visualization. This study investigates the growth status in ABD related research which can help the policy maker, researchers and people of agriculture and allied sector to have an exhaustive understanding on Agriculture Big Data research for further study.

Keywords : Agriculture Big Data, Internet of Things, Scientometrics, Visualizations, Big Data, Co-citation analysis

Introduction:

Due to the exponential development of IoT (Internet of Things) devices, we are generating huge amount of data from everyday activity without realizing how exactly big they are. Big Data is a common slang being used among business enterprises and scientific research society. Big Data is nothing but huge amount of data which is very complex to analyze and difficult to manage, record or store with existing traditional data processing applications or tools. The concept of 'Five V' is generally refers to understand the concept of big data ie, Volume, Variety, Velocity, Value and Variability. According to Forbes, by the year 2020 about 1.7 megabytes of data will be generated every second for every human being on the earth. Like every other sector, big data has attracted the agriculture sector as well. For greater resolution and greater frequency satellite and aerial images, for real time monitoring of crops growth, weather forecasting data etc are some of the areas in today's agriculture hits by big data analytics. Across the agriculture community, big data is generally considered to be as a amalgamation of ICT (Information and Communication Technology) and analytics that can gather and compile research data, and process data in a more efficient and timely manner to assist decision and policy-making. (Stubbs, Big Data in U.S. Agriculture, Congressional Research Service, 2016).Big data intervention further includes meteorological data, survey data, financial data, soil, water, and geospatial based data, external market data (price and sales data), open government data, and social media based data. Apart from these technical importance, big data can also be used for accurate and timely crop yield forecasting, minimize farmers risk in production, food safety measures and agriculture equipments management. The IoT concept intervention in agriculture made it to be termed as Internet of Agriculture Things (IoAgT).

'Scientometric' is a generic surrogate term what Pritchard called 'Bibliometric' and is defined as the study of the quantitative aspect of science and technology and its communication. Scientometric is used for measuring and mapping the science and its related discipline. It is used as science mapping tool which can be seen with its two advantages : 1) it provides an analysis of a research trend in a defined geospatial region within a limited timeframe using various indicators; 2) it assess science as a knowledge producing system.

Therefore now a days bibliometric method has evolved as an essential tool for measuring scientific communication and growth. Traditionally the bibliometric method is being used in librarianship and Information science field to analyze the citation characteristics, content analysis etc but now a days it is widely being used for measuring country scientific performance, Institutional research performance, authors impact over a period of time, global and institutional collaboration, journal and other sources performance and growth and to analyze their citation structure.The present study is a scientometric and visualization study of 379 research publications in Agriculture Big Data research. however there is little research on Agriculture Big Data as per as is quantification and visualization aspect is concern. Co-authorship analysis, Keyword Co-occurrence and Co-citation analysis of these publications have been performed to find out the research scenario in Agriculture Big Data research.

1. Objectives of the study:

mapping scientific structure of Agriculture Big Data research through scientometric analysis, visualization and network analysis.

2. Methods and Data collection :

The publication data for performing this study were searched and downloaded from Clarivate Analytics (earlier Known as Thomson Reuters) Web of Science product name SCI-Expanded. SCI-Expanded database is now a day's being used for most of the Citation analysis and Science Mapping studies. The Search Strategy was made and conducted on 20 January 2019 by providing topical keyword "Agriculture Big Data" with enabling time span of "All Years" and Documents types "All types". The time span 'All years' was enabled to cover maximum number of publications. A total of 379 publications fulfilled the desired search query which comprises mainly 5 documents types. Maximum number of document types were Article types with 330 articles comprises 87.07% of the total publications, followed by 29 review publications comprises 7.65% of the total publications, and 13 proceedings papers comprises 3.43% of the total shared publications. Table 1 comprises with the data regarding Documents types and their distribution.

Table 1. Document types and distribution

	Frequency	**Distribution(%)**
ARTICLE	330	87.07
REVIEW	29	7.65
PROCEEDINGS PAPERS	13	3.43
EDITORIAL MATERIALS	4	1.06
BOOK CHAPTERS	2	0.53
REVIEW, BOOKCHAPTER	1	0.26
Total	379	100.00

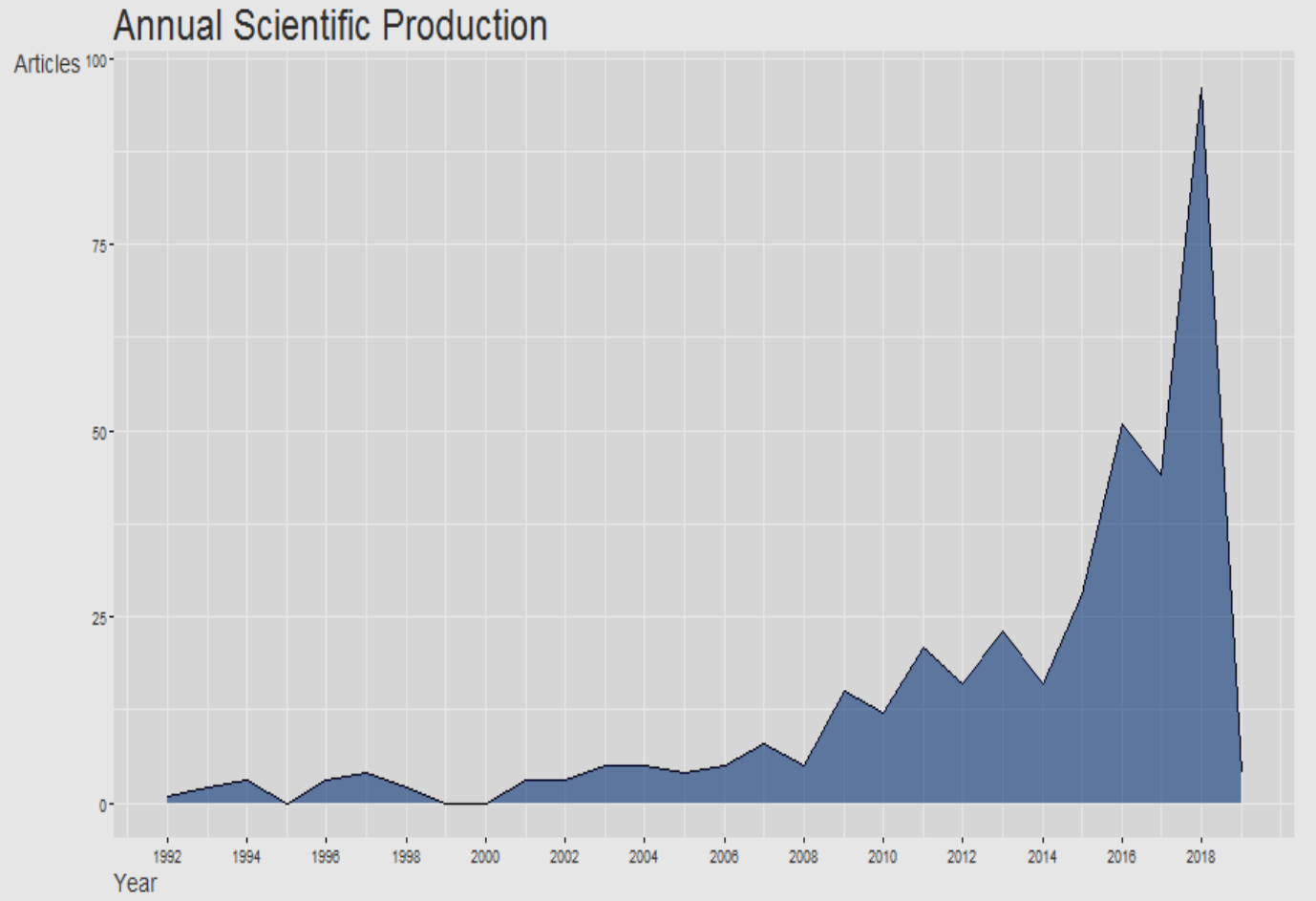
Mapping of a discipline or a specified subject area includes many manifolds analysis and structural representation of the scientific data. In this study we used Visualization Of Similarity (VOS) Viewer software to visualize scientific landscape specially complex scientometric relations such as Co-citation analysis and Co-word occurrence analysis in Agricultural Big Data (ABD) research. MS-Excel and R statistical Software program is used as analysis tool to analyze different scientific structure based on different Scientometric indicators.

3. Data Analysis and Results:

3.1 Annual Scientific Production

Annual scientific production trends in terms of publications is represented in figure 1. The earliest ABD related publication is recorded way back in 1992 and since then its annual growth is not so splendid. Only after 2012 and 2013 onwards, the Agriculture Big Data research has got some pace as the horizon of big data has scattered widely in to the agriculture and its derivative discipline. With the elevated use of information and communication technology in agriculture sector, scientists, farm managers, subject matter specialists other agricultural professionals and even farmers are intended to obtain enormous agricultural data. year 2018 was the most productive year with 96 publications recorded, followed by the year 2016 with 51 publications, year 2017 with 44 publications in ABD research. Year 1992 was the least productive year with just a single publication recorded in it. Non-rapid annual production growth has recorded as many developing nations are still in the indecision or initial stage of Implementing Big Data and Analytics in Agriculture sector.

Figure 1. Annual Scientific production in ABD publications.



3.2 Top 25 most productive sources exhibited with ABD publications

All the recorded 379 publications were from 285 journals sources. Out of total 285 journals, 233 (61.48%) journals published one paper only, while we recorded only 19 (5.01%) journals which having more than 2 papers. The most productive journal we analyzed with maximum 8 publications was *Computers and Electronics in Agriculture*, followed by *International Food and Agribusiness Management* with 7

publications. These two were the only two journals with more than 5 publications. Table 2 along with Figure 2 shown below the most productive 20 journals published papers in ABD research.

Table 2. top 20 most relevant sources

Sources	Publications
COMPUTERS AND ELECTRONICS IN AGRICULTURE	8
INTERNATIONAL FOOD AND AGRIBUSINESS MANAGEMENT REVIEW	7
JOURNAL OF CLEANER PRODUCTION	5
JOURNAL OF FOOD AGRICULTURE & ENVIRONMENT	5
SENSORS	5
AGRICULTURAL ECONOMICS-ZEMEDELSKA EKONOMIKA	4
AGRICULTURAL SYSTEMS	4
CHINA AGRICULTURAL ECONOMIC REVIEW	4
ENVIRONMENTAL MODELLING \& SOFTWARE	4
REMOTE SENSING OF ENVIRONMENT	4
SCIENCE OF THE TOTAL ENVIRONMENT	4
SOCIOLOGIA RURALIS	4
WATER SCIENCE AND TECHNOLOGY	4
APPLIED GEOGRAPHY	3
BERICHTE UBER LANDWIRTSCHAFT	3
ENVIRONMENTAL EARTH SCIENCES	3
IEEE JOURNAL OF SELECTED TOPICS IN APPLIED EARTH OBSERVATIONS AND REMOTE SENSING	3
JOURNAL OF ANIMAL SCIENCE	3
LAND USE POLICY	3
AFRICAN JOURNAL OF AGRICULTURAL RESEARCH	2

3.3 Author's productivity in terms of h-index, g-index, m-index, Total Citations (TC) and Total Publications (TP)

Jorge Eduardo Hirsch, an argentine American professor of physics in the year 2005 invented h-index. The index is based on the citations distribution of an individual author's publications. h-index is an author level matrix which may be defined as an author has a h-index of 'h' when they have h papers that have been cited at least h number of times. h-index was treated as a reliable and authentic tool for mapping scientific contribution and attainment of an individual author. G- index was proposed by Leo Egghe as a modified version of h-index and it is formulated as, after arranging all the publications in decreasing order of citations they recieved, g-index is the top g number of articles received g citations together.. table 3 is the analysis of author's productivity in terms of Total number of publications(TP), Total number of Citations(TC), h-index and g-index in Agricultural Big Data research.The study revealed that apart from the top 4 or 5 authors in terms of h-index, most of the authors had similar citation and publication characteristics. following is the table 3 with top 20 authors and their productivity with matrices.

Table 3. top 20 authors and their productivity

Authors	h-index	g-index	TC	NP
[ANONYMOUS] A	12	19	415	56
WANG Y	3	5	174	5
ZHANG H	3	3	50	3
HAN R	2	3	150	3
AKCAOZ H	2	2	132	2
TIEN JM	2	2	80	2
HORAN H	2	3	62	3
GARCIA JN	2	2	60	2
GOBBETT D	2	2	60	2
HOCHMAN Z	2	2	60	2
HOLZWORTH D	2	2	60	2
MARINONI O	2	2	60	2
MCCLELLAND T	2	2	60	2
VAN REES H	2	2	60	2
RODRIGUEZ D	2	2	52	2
VAN WIJK MT	2	2	52	2
WANG X	2	5	52	5
FANG H	2	2	41	2
WEERSINK A	2	2	39	2
CHEN B	2	2	32	2

3.4 *most cited country and average article citation gained in ABD publications*

table 4 displays the top 20 most cited countries in agriculture big data research. United states took the prime position with a total of 1132 citations from 76 contributed papers with 14.90 of average article citation till the research was conducted. This is because in USA implementation of ICT and data analytic tools specially big data analytic in agriculture sector is highly promoted, although many top producers in the country decided to wait for using big data in agriculture over traditional methods due to having a fear of lopsided or crooked marketing information, accessibility, possession and privacy of data. Just like USA, China is propagating their big data research having the second most cited country with a total of 530 citations from 49 contributed papers indexed in web of Science database with an average article citation of 10.82. This may be due the fusion of many tech companies in 2018 China international big data fusion innovation and artificial intelligence global competition. GAGO tech company with their farmers linking Software as a service (SaaS) based cloud service in agriculture is considered to be a big shot in big data implementation in agriculture sector. Following is the table 4 displaying the top 20 most cited countries with their total citations count, total articles and average article citations.

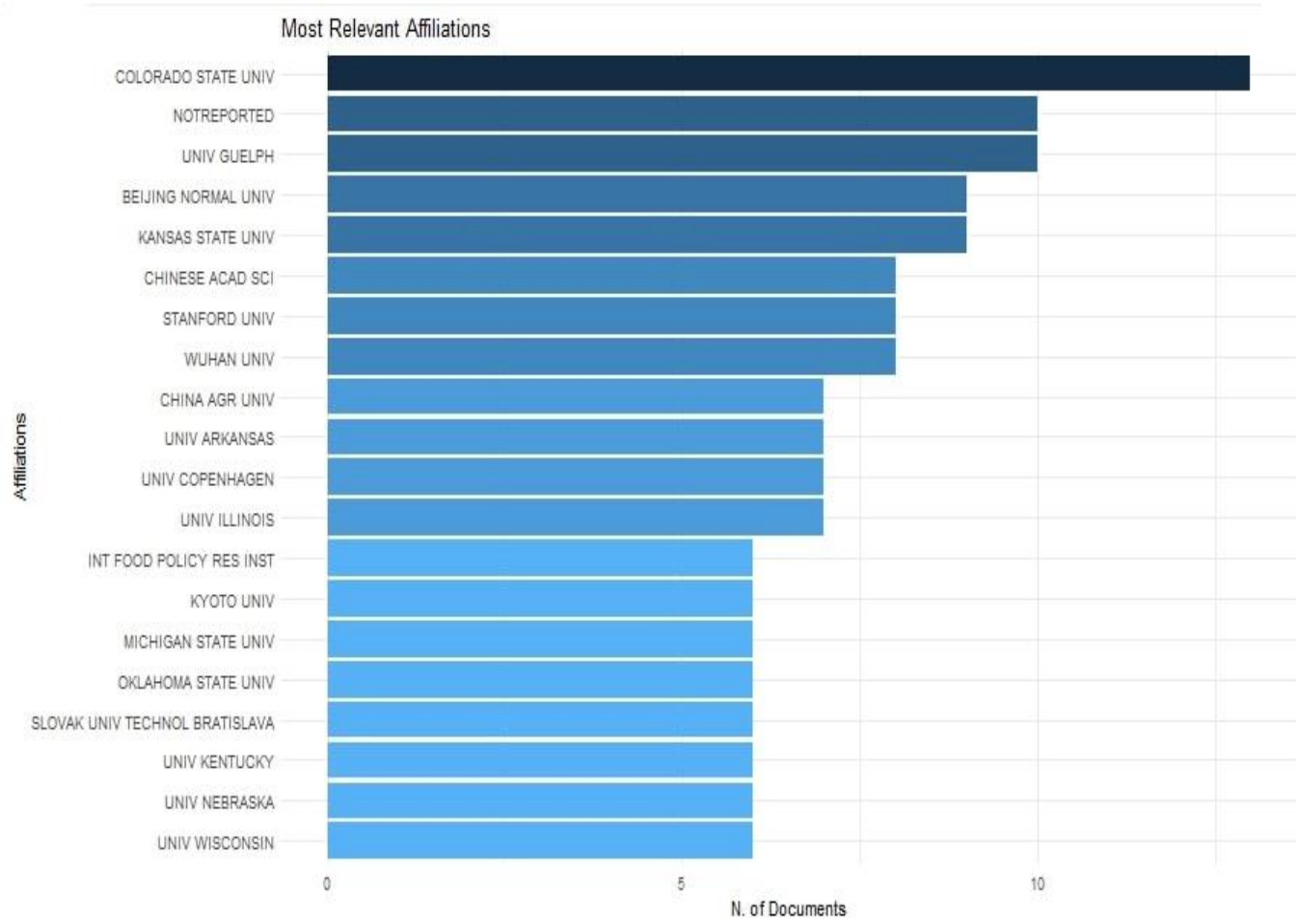
Table 4. top 20 most cited countries

Country	Total Citations	Total Articles	Average Article Citations
USA	1132	76	14.90
CHINA	530	49	10.82
GERMANY	388	24	16.17
UNITED KINGDOM	196	15	13.07
TURKEY	177	12	14.75
NETHERLANDS	90	3	30.00
AUSTRALIA	87	7	12.43
ITALY	81	8	10.13
CANADA	79	12	6.58
SPAIN	76	6	12.67
UKRAINE	57	1	57.00
FRANCE	50	9	5.56
KENYA	47	1	47.00
POLAND	42	7	6.00
BRAZIL	36	16	2.25
BELGIUM	34	5	6.80
IRAN	34	4	8.50
INDIA	32	17	1.88
SLOVAKIA	32	4	8.00
COLOMBIA	30	2	15.00

3.5. *most relevant affiliation related to ABD publications*

Figure 2 displays the most relevant affiliations from which agriculture big data research publications has been carried out. As we have already seen that USA was the dominant country in terms of number of papers and citation count, Colorado state university situated in Fort Collins has topped the list with maximum 13 publications followed by University of Guelph in Ontario, Canada with 10 publications. Beijing Normal University in Beijing and Kansas State University in Kansas, Manhattan USA were the next two prolific institutions with 9 publications each. Chinese Academy of Science china, Stanford University USA and Wuhan University were the next affiliated institutions where notable agriculture big data research has been performed. It is interesting to see that four institutions out of top 10 are Chinese and 3 are USA based institutions. following is the figure 2 which displays the top 20 most relevant affiliation in terms of number of publications in agriculture big data research.

Figure 2. Top 20 most relevant affiliations



3.6. *top 20 Corresponding authors country and publications*

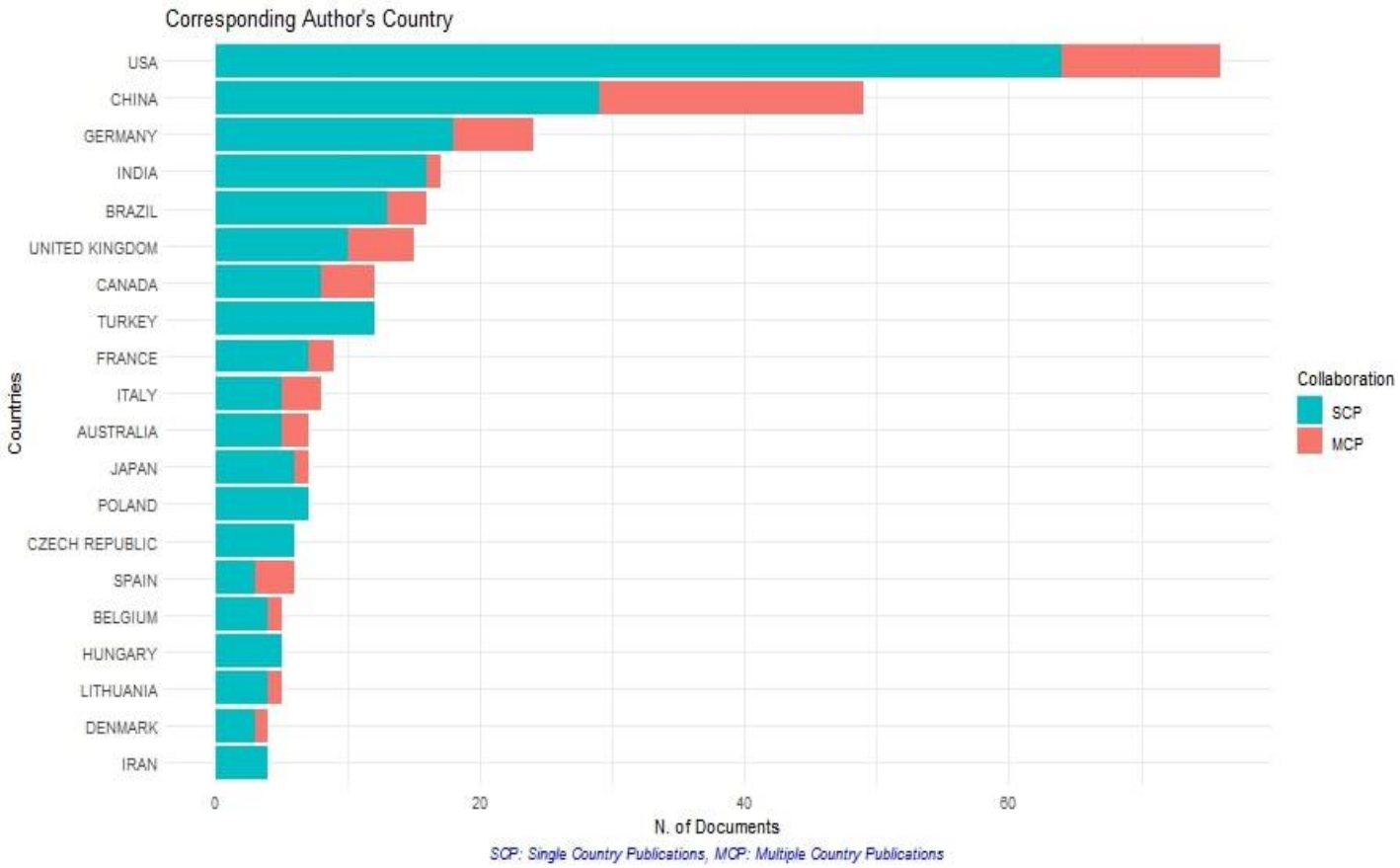
Table 5 exhibit the list of corresponding authors country with their number of publications and analysis of number of single country publication(SCP), multiple country publication(MCP) and multiple country publication Ratio. USA was the leading country with a total of 76 publications out of those 64 were single country and 12 were multiple country publications with a MCP ratio of 0.16 which shows majority of the publications on ABD research in United States were single country published. While China on the other hand with a grand MCP ratio of 0.41 resides on the second place showing although single country publications was more (29) but considerable number of 20 publications were multiple country publications. The high MCP ratio shows the greater collaboration of a country with other countries. Germany and India

respectively were the third and fourth corresponding countries in the list with 6 out of 24 (MCP 0.25) and 1 out of 17 (MCP 0.06) multiple country publications. following is the table 5 displaying the list of top 20 corresponding authors countries and publications. Figure 3 is the graphical representation of the corresponding authors country and publications.

Table 5. top 20 corresponding authors country and publications

Country	Articles	SCP	MCP	MCP Ratio
USA	76	64	12	0.16
CHINA	49	29	20	0.41
GERMANY	24	18	6	0.25
INDIA	17	16	1	0.06
BRAZIL	16	13	3	0.19
UNITED KINGDOM	15	10	5	0.33
CANADA	12	8	4	0.33
TURKEY	12	12	0	0.00
FRANCE	9	7	2	0.22
ITALY	8	5	3	0.38
AUSTRALIA	7	5	2	0.29
JAPAN	7	6	1	0.14
POLAND	7	7	0	0.00
CZECH REPUBLIC	6	6	0	0.00
SPAIN	6	3	3	0.50
BELGIUM	5	4	1	0.20
HUNGARY	5	5	0	0.00
LITHUANIA	5	4	1	0.20
DENMARK	4	3	1	0.25
IRAN	4	4	0	0.00

Figure 3. top 20 Corresponding authors country and publications



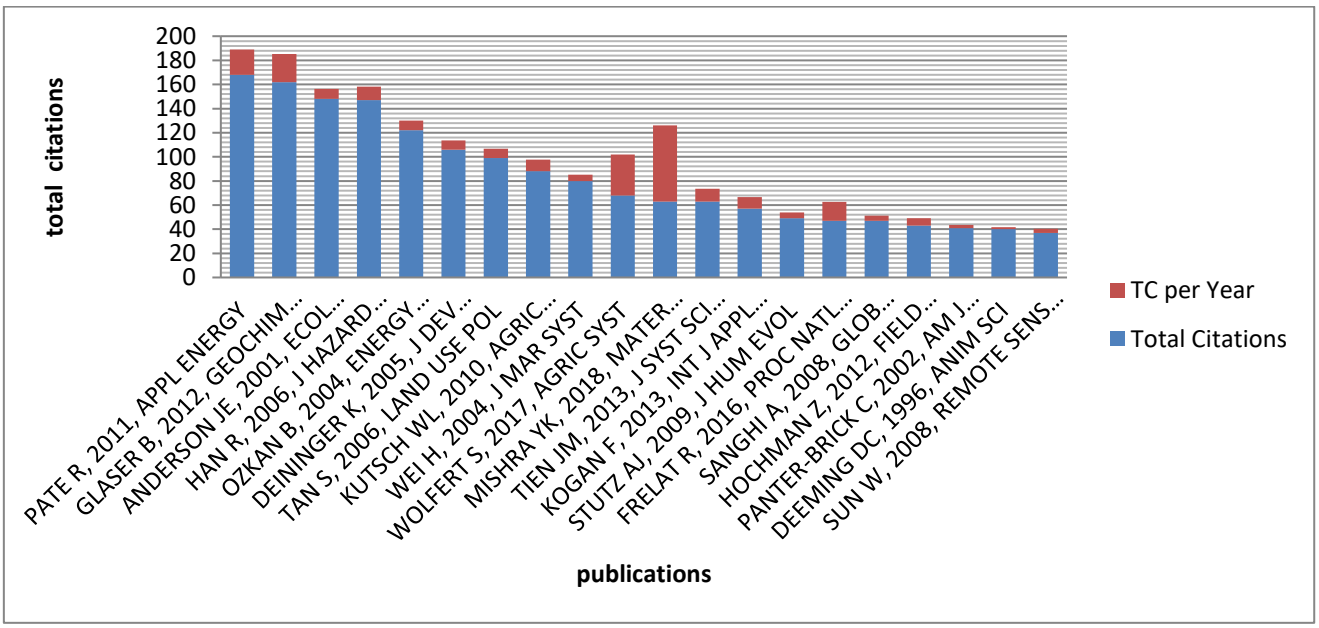
3.7. *top 20 most cited publications*

table 6 unveil 20 most cited publications in ABD research. the publication authored by PATE R; KLISE G and WU B. entitled '*RESOURCE DEMAND IMPLICATIONS FOR US ALGAE BIOFUELS PRODUCTION SCALE-UP*' published in applied energy in the year 2011 got the maximum 168 citations with per year citation count of 21. table 6 and figure 4 shows the list of top 20 most cited publications with their respective authors, year of publications and journals in which these are published.

table.6 Top 20 most cited publications

Publications	Total Citations	TC per Year
PATE R, 2011, APPL ENERGY	168	21
GLASER B, 2012, GEOCHIM COSMOCHIM ACTA	162	23.14
ANDERSON JE, 2001, ECOL MONOGR	148	8.22
HAN R, 2006, J HAZARD MATER	147	11.31
OZKAN B, 2004, ENERGY CONV MANAG	122	8.13
DEININGER K, 2005, J DEV ECON	106	7.57
TAN S, 2006, LAND USE POL	99	7.62
KUTSCH WL, 2010, AGRIC ECOSYST ENVIRON	88	9.78
WEI H, 2004, J MAR SYST	80	5.33
WOLFERT S, 2017, AGRIC SYST	68	34
MISHRA YK, 2018, MATER TODAY	63	63
TIEN JM, 2013, J SYST SCI SYST ENG	63	10.5
KOGAN F, 2013, INT J APPL EARTH OBS GEOINF	57	9.5
STUTZ AJ, 2009, J HUM EVOL	49	4.9
FRELAT R, 2016, PROC NATL ACAD SCI U S A	47	15.67
SANGHI A, 2008, GLOB ENVIRON CHANGE-HUMAN POLICY DIMENS	47	4.27
HOCHMAN Z, 2012, FIELD CROP RES	43	6.14
PANTER-BRICK C, 2002, AM J HUM BIOL	41	2.41
DEEMING DC, 1996, ANIM SCI	40	1.74
SUN W, 2008, REMOTE SENS ENVIRON	37	3.36

Figure.4 *top 20 most cited publications*

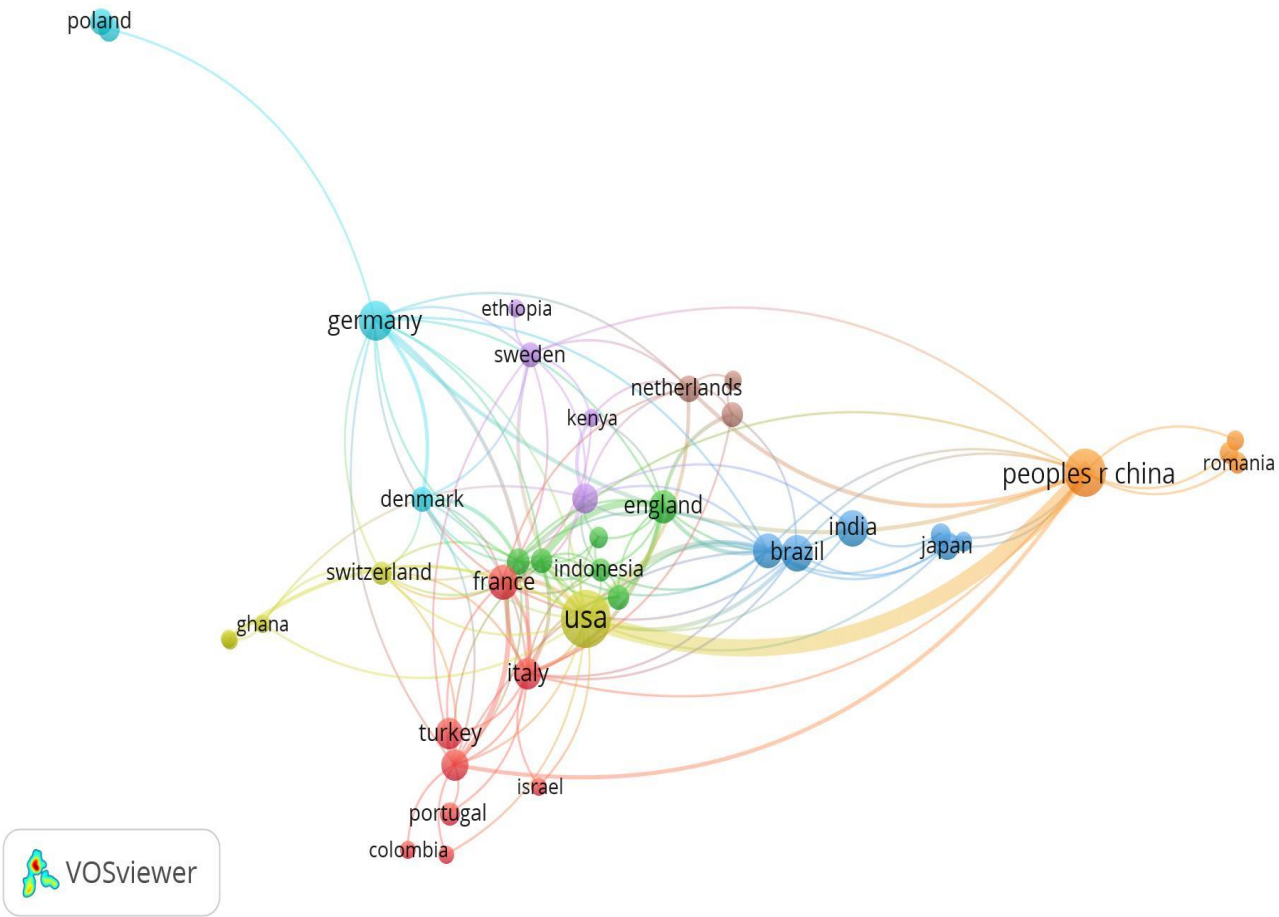


4. Structural Analysis and Visualization in ABD research publications

4.1 Co-authorship (countries) in ABD publications

Global country co-authorship network has been created using VOSviewer software (see, figure 5). In the analyzed figure a node symbolizes a country while the size of the node represents the activity of the country. The curved line between the two nation shows the publication collaboration relationship between them. The thickness of the curve shows the extent of collaboration between the respective countries. For this analysis the defined criteria was set up. Only those countries have been taken for the study which having at least 2 publications and 2 citations. The software analyzes the manually defined criteria and out of 74 such countries 47 met the threshold. for each of the 47 countries the total strength of the co-authorship link with other countries has been calculated. the maximum number of countries found connected and form clusters were 40. Therefore the co-authorship analysis of these 40 countries has been performed. The software separates these 40 countries into 8 clusters which forms 144 links with a total link strength of 185. China and the USA have thick curved line between them which determines the strong mutual cooperation between the two countries. In addition, USA has the total links strength of 46 with the other countries, while the China has the total link strength of 28 with other countries. The total link strength represents co-occurrence frequency. The big nodes represents the prolific countries. from the figure it is clear that Agriculture Big Data research is mainly centralized in either United States or in China with having great mutual cooperation. The link strength between USA and China is 12, between the USA and England being 3, and between Germany and Italy being 2. Therefore geospatial based analysis is a crucial stage in order to find out the global cooperation in Scholarly communication.

Figure.5 Co-authorship network analysis in ABD Publication



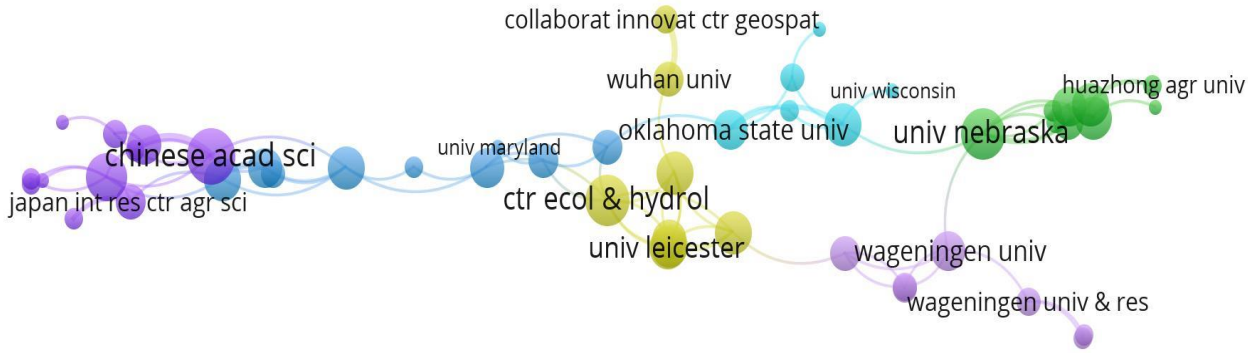
4.2 *Organizational Co-authorship analysis in ABD publications*

The organizational co-authorship network is represented in figure 6. Chinese academy of science and Chinese academy of agriculture science are the two most prolific organizations of China while Centre for ecology and hydrology and University of Nebraska are the two most prolific organizations in USA are responsible for the major co-authorship works in Agriculture Big Data research. table 7 shows the list of top 10 organizations with their documents, citations and total link strength.

Table 7. top 10 organizational co-authorship analysis in ABD publications

Organization	Documents	Citations	total Link Strength
chinese acad sci	14	70	9
ctr ecol & hydrol	2	21	8
univ nebraska	4	13	8
chinese acad agr sci	5	36	7
chinese agr univ	3	30	6
int food policy res int	4	129	6
kanesas state univ	5	7	6
michigan state uni	4	20	6
noaa	2	18	6
univ calif danis	4	59	6

Figure. 6 organizational co-authorship analysis in ABD publications



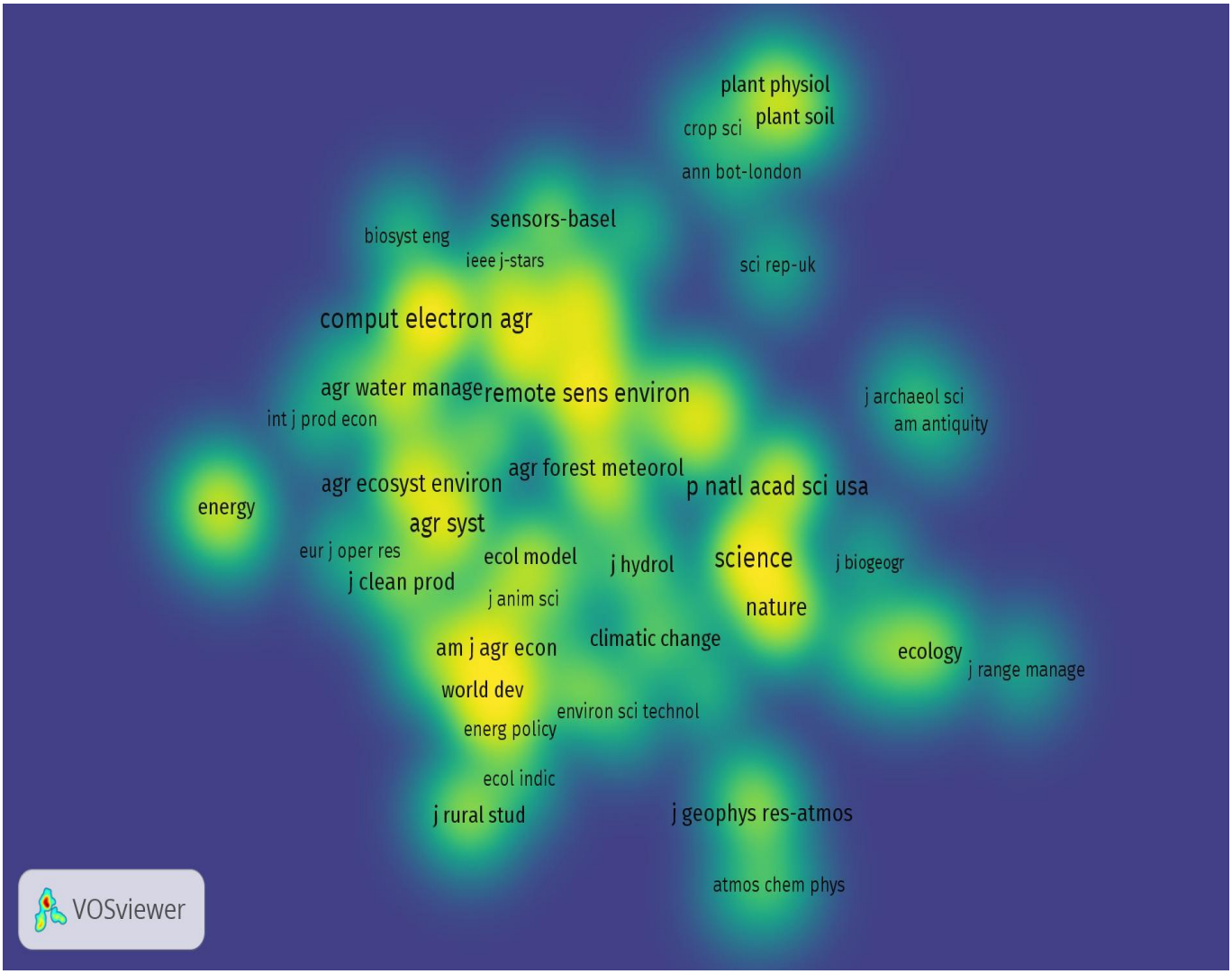
4.3 Co-citation analysis (cited sources) in ABD publications

when two sources or authors are cited in a citing document's reference list, they form a co-citation relationship. Small devised co-citation study to find out the structure of any discipline. Journal or Source co-citation analysis is a potential method to analyze the overall structural horizon of any subject and its related sources. The software analyzes the cited sources used in ABD research. A total of 93 nodes identified which formed 6 clusters, 2653 links with a total link strength of 39246. Here we have created a network of density visualization of cited sources in ABD research. *Computers and Electronics in agriculture* is the most prolific source with a total link strength of 3838. Sources with higher link strength are more denser than those having lower link strength.

Table 8. top 10 sources with their total link strength

sources	citations	total link strength
comput electron agr	148	3838
agr ecosyst environ	98	3328
Science	166	3251
remote sense environ	136	3124
int j remote sens	79	2694
agr syst	116	2471
p natl acad sci usa	108	2263
nature	105	2214
agr water manage	57	1693
remote sens basel	68	1614

Figure7. density analysis of co-citation of cited sources in ABD publications



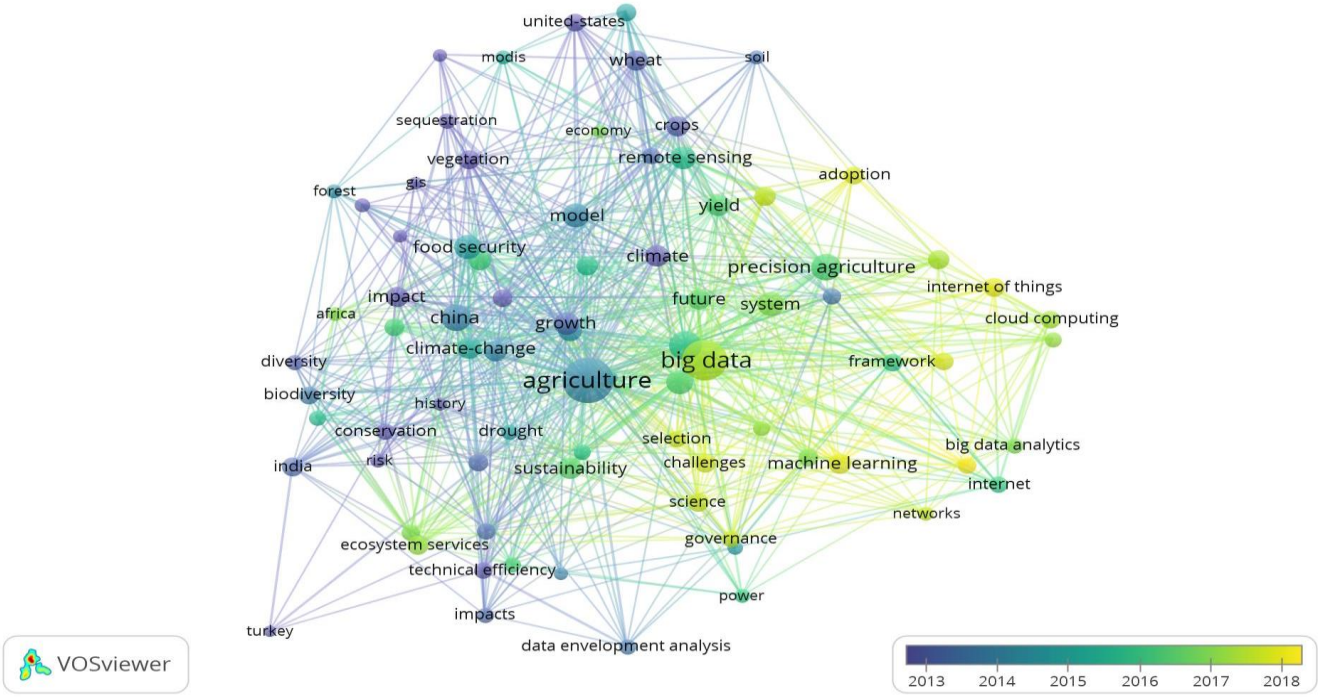
4.4 Keyword Co-occurrence Analysis

keyword co-occurrence analyzes the research hotspot in a discipline. It also studies the research trends in a defined domain. we set the criteria on minimum 1 keyword occurred in the study and we found total 2513 keywords. Out of these 2513 keyword, 81 keywords occurred at least 5 times forming 3.23% of the total keywords. table 9 is the list of top 10 most occurred keyword used in ABD research. for each of the 81 keywords , the total link strength of co-occurrence links with other keywords has been calculated. As expected 'agriculture' was the most occurred keyword with a frequency of 96 and a total link strength of 254 followed by 'big data'. The overlay analysis shows the co-occurrence of keywords in a stipulated time frame. it is clear from the figure that, the keywords occurred in ABD research like big data, cloud computing, internet of things, machine learning, precision agriculture etc are evolve only since the beginning of 2016 till now. The analysis show that due to the implementation of big data in agriculture sector, the research areas such as precision agriculture, remote sensing and systems, management in agriculture have elevated.

Table 9. top 10 most occurred keyword used in ABD research

keywords	occurrences	links	total link strength
agriculture	96	74	254
big data	66	63	189
china	24	47	64
management	22	33	80
precision agriculture	20	36	69
model	16	30	54
system	16	32	53
remote sensing	16	31	48
systems	15	31	50
food security	12	31	54

Figure 9. keyword co-occurrence analysis in ABD research



5. Conclusions

An extensive Scientometric study on Agriculture Big Data research has been performed through Clarivate Analytics Web of Science database based data with a time span of all years. Various study have been performed in terms of Scientific publication production, authors and affiliations performances, citation characteristics of publications in ABD research, network analysis and visualizations of co-authorship, co-citations and keyword co-occurrences have been performed. following results can be drawn from the above study:

- Although the first publication traced way back in 1992, the research in ABD has not been in splendid growth. however in the recent years number of publications increases due to the elimination of ignoring big data tools in agriculture.
- Through the analysis of keywords it may be observed that the traditional research topics obsolete and research on new topics such as cloud based agriculture system, precision agriculture, application of remote sensing and GIS have been elevated.
- USA and China evolved as the two leading countries not only in terms of number of publications but also in terms of citation counts, h-index and scientific collaboration.
- Chinese and American institutions have contributed more than other nations shows that these two nations paid attention in this field, although china has greater collaboration with other countries than USA in ABD publications.

References:

1. Chawla, N. V., & Davis, D. A. (2013). Bringing big data to personalized healthcare: a patient-centered framework. *Journal of general internal medicine*, *28*(3), 660-665.
2. Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M. J. (2017). Big data in smart farming–a review. *Agricultural Systems*, *153*, 69-80.
3. Bronson, K., & Knezevic, I. (2016). Big Data in food and agriculture. *Big Data & Society*, *3*(1), 2053951716648174.
4. Tang, M., Liao, H., Wan, Z., Herrera-Viedma, E., & Rosen, M. (2018). Ten years of sustainability (2009 to 2018): A bibliometric overview. *Sustainability*, *10*(5), 1655.
5. Liao, H., Tang, M., Luo, L., Li, C., Chiclana, F., & Zeng, X. J. (2018). A bibliometric analysis and visualization of medical big data research. *Sustainability*, *10*(1), 166.
6. Moed, H., De Bruin, R., & Van Leeuwen, T. H. (1995). New bibliometric tools for the assessment of national research performance: Database description, overview of indicators and first applications. *Scientometrics*, *33*(3), 381-422.
7. Liu, W., & Liao, H. (2017). A bibliometric analysis of fuzzy decision research during 1970–2015. *International Journal of Fuzzy Systems*, *19*(1), 1-14.
8. Cobo, M. J., Martínez, M. A., Gutiérrez-Salcedo, M., Fujita, H., & Herrera-Viedma, E. (2015). 25 years at knowledge-based systems: a bibliometric analysis. *Knowledge-Based Systems*, *80*, 3-13.
9. Merigó, J. M., Gil-Lafuente, A. M., & Yager, R. R. (2015). An overview of fuzzy research with bibliometric indicators. *Applied Soft Computing*, *27*, 420-433.

10. Barr, B. (2015, Sep 30). Big Data: 20 Mind-Boggling Facts Everyone Must Read. Retrieved from https://www.forbes.com/sites/bernardmarr/2015/09/30/big-data-20-mind-boggling-facts-everyone-must-read/.

11. Shekhar, S., Schnable, P., LeBauer, D., Baylis, K., & VanderWaal, K. (2017). Agriculture Big Data (AgBD) Challenges and Opportunities From Farm To Table: A Midwest Big Data Hub Community Whitepaper.

12. van Eck, N., & Waltman, L. (2009). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, *84*(2), 523-538.

13. Aria, M., & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, *11*(4), 959-975.

14. Du, H., Li, N., Brown, M. A., Peng, Y., & Shuai, Y. (2014). A bibliographic analysis of recent solar energy literatures: The expansion and evolution of a research field. *Renewable Energy*, *66*, 696-706.

15. Pritchard, A., & Wittig, G. R. (1981). *Bibliometrics*. AllM Books.

16. Hood, W., & Wilson, C. (2001). The literature of bibliometrics, scientometrics, and informetrics. *Scientometrics*, *52*(2), 291-314.

17. Carbonell, I. (2016). The ethics of big data in big agriculture. *Internet Policy Review*, *5*(1).

18. Sonka, S. (2014). Big data and the ag sector: More than lots of numbers. *International Food and Agribusiness Management Review*, *17*(1030-2016-82967), 1.

19. Kamilaris, A., Kartakoullis, A., & Prenafeta-Boldú, F. X. (2017). A review on the practice of big data analysis in agriculture. *Computers and Electronics in Agriculture*, *143*, 23-37.

20. Tsay, M. Y. (2008). A bibliometric analysis of hydrogen energy literature, 1965–2005. *Scientometrics*, *75*(3), 421-438.